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Discussion

Author's reply

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The author would like to express his gratitude to Sims and Stanway [1] for their comments on the paper [2]. As you mentioned in Ref. [1], it is necessary to have an accurate damping force model that can capture the inherent hysteresis behavior of electro-rheological (ER) and magneto-rheological (MR) dampers. The accuracy of the damper model also significantly affects control performance in the feedback system. So far, various types of damper models—hysteretic Bingham plastic model, hysteric biviscous model, nonlinear viscoelastic plastic model, Bouc–Wen model and polynomial model have been proposed to capture the hysteretic characteristics of the ER or MR damper. However, these models cannot describe the flow motion of the damper, which is an inherent feature in hydraulic ER or MR damper mechanisms.

The hydro-mechanical model proposed in the paper [2] has been derived from the lumped hydraulic components of ER damper. Therefore, this model well describes the flow motion of the ER or MR damper which can be observed in general hydraulic systems [3]. For example, the principal parameters in the hydraulic system such as the fluid inertia, flow resistance and control volume are considered in the model shown in Fig. 3(a) in the paper [2]. By considering these parameters, we can easily evaluate the field-dependent damping and stiffness characteristics with various frequency and excitation amplitudes. In addition, we can identify the relationship between hydraulic parameters and mechanical parameters using the proposed hydro-mechanical model. This is very important to determine design parameters associated with fluid characteristics of ER or MR fluid.

Consequently, the author would like to say that even though the mechanical model shown in Fig. 3(b) which is equivalent to the hydro-mechanical model has very similar characteristics to the models proposed in the papers [4–6], the proposed hydro-mechanical model is another effective model to capture the filed-dependent hysteretic behaviors of ER or MR damper system.

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